THE APPLICATION OF SCINTILLATION COUNTER TECHNIQUES TO NUCLEAR SPECTROSCOPY

BY

SHERMAN FRANKEL

B.A., Brooklyn College, 1943
M.S., University of Illinois, 1947

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYSICS
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The problems entering into the design of a scintillation spectrograph and the methods used to attain linearity are discussed. Resolution and transmission for this type of spectrograph are compared with a lens type spectrograph by means of measurements on Cs^{137}. The resolution of the scintillation spectrograph for the Cs^{137} 626 kev. internal conversion line was measured as 12.5% (in momentum) when using an electronic resolution of 3.0%. The Fermi plot of the beta spectrum in Cs^{137} is linear down to about 200 kev. The role of linearity and threshold of detection in determining γ -ray efficiencies is treated. An upper limit for the detection threshold of our scintillation system is obtained by comparison with a Geiger counter, using a commercial x-ray tube as a source of x-rays whose peak energy is variable. It is shown experimentally that the detection threshold lies below 14 kev. Arguments are advanced in favor of an even lower threshold. It is also shown that, above 14 kev., the "detection efficiency" is 100%. The use of scintillation counters for measurements of short time intervals is considered. The problems inherent in the design of a special electronic system that makes use of the speed of the counter is discussed.

A complete electronic system, designed specially for scintillation counter use, is presented. Characteristics of a linear, wide-band pre-amplifier and amplifier are listed. A moderately accurate pulse height discriminator and pulse shaper for use in un-delayed coincidence measurements is described briefly. Special "superamplifier" and "evener" circuits, used for delayed coincidence measurements in conjunction with the linear amplifier, are described. The design of an amplifier with high dynamic range and short recovery time is discussed. Pertinent details of an n-channel delayed coincidence circuit, possessing a stable and easily varied resolving time, are presented. Special emphasis is placed on the description of a

highly accurate and stable pulse height selector for use with scintillation spectrographs and proportional counters.

Scintillation counting techniques have been successfully applied to the measurement of beta-gamma angular correlations in Rb^{86} and Au^{198}. This has made possible the assignment of spins of 2 to both Rb^{86} and the excited state of Sr^{86}. The correlation requires that both beta transitions in Rb^{86} obey Gamow-Teller selection rules (tensor or axial vector interactions, first forbidden, $L = 2$). Parity considerations specify the gamma radiation as $L = 2$ electric. The spin of Rb^{86} is verified by re-analysis of the published beta-ray spectrum. The angular correlation in Au^{198} is found to be isotropic, in agreement with the shape of the beta-spectrum. The theory of beta-gamma correlations is briefly reviewed and the experimental apparatus described.

The results of the application of scintillation counter techniques to the measurement of short half-lives in Ge^{72}, Hg^{198}, Te^{123} and Te^{121} are presented. The lifetime of the short-lived state in Ge^{72} is measured to be $.33 \pm .09$ microseconds. The results of McGowan, et al on the existence of a short-lived state in Hg^{198} are verified. Delayed coincidence experiments on Te^{121} fail to show the presence of a measurable lifetime. This is difficult to reconcile with the previously reported lifetime of $.05 \pm .02$ microseconds.

The problems inherent in measurements of internal conversion coefficients are discussed. The K conversion coefficient of the 35.4 kev. transition in Te^{125} is determined to be $.69 \pm .03$.

VITA

Sherman Frankel was born in New York City on November 15, 1922. He attended Brooklyn College from September 1939 to May 1943 receiving the Bachelor of Arts degree with majors in both Physics and Chemistry.

From June, 1943 until February, 1946 he was a staff member at the Radiation Laboratory of the Massachusetts Institute of Technology. His work consisted of electronic design and development under the wartime O.S.R.D. program. He was the author of several Radiation Laboratory Technical Reports and contributed to the writing of Volume 16 of the M.I.T. Radiation Laboratory Series.

From March 1946 until September 1949 he was a student in the Graduate College at the University of Illinois. During this time he was employed as a Teaching or Research Assistant in the Department of Physics. In June 1947 he received the degree of Master of Science in Physics.

He is associated with Sigma Xi, Pi Mu Epsilon, and the American Physical Society.

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